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NOTES ON GEOGRAPHIC DISTRIBUTION

Girardia festae (Borelli, 1898) (Platyhelminthes: Tricladida: Dugesiidae): Distribution extension in a high-altitude lake from Colombia

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ABSTRACT: We revise the Neotropical distribution of *Girardia festae* (Platyhelminthes, Dugesiidae) following a new record in a Colombian high-altitude lake. *G. festae* is a freshwater planarian known mainly in the Andean Cordillera from Venezuela to Argentina. The species' key reproductive features include: ventral testes, bottle-like penis papilla, and sperm ducts joining to the penis bulb latero-dorsally.

Freshwater planarians feature low diversity in the Neotropics relative to elsewhere (Sluys *et al.* 2005). The family Dugesiidae (Geoplanoidea, Continenticola) in the Neotropics comprises 31 species of *Girardia* and one of *Romankenkius.* Five *Girardia* species have been cited in Colombian high-altitude freshwater bodies (Table 1). The species *Girardia festae* (Borelli, 1898) is known from 31 localities in 9 countries that mostly span the South American Andes (Figure 2). For Colombia, only one previous record exists, dating back to the beginning of last century (Table 2). We herein update the distribution of *G. festae* in the Neotropics.

FIGURE 1. Study site at Cristalina lake (Iguaque-La Rusia-Guantiva Forest Consevation Corridor, Boyacá, Colombia).

We collected specimens in December 2007 during a macrofauna survey in 3 high-altitude lakes in the Andean Páramo (Boyacá, Colombia). All individuals were found in Cristalina lake (1.5 ha area, 9.0 m maximum depth) at 3,745 masl (05°57'35" N, 73°05'04" W) (Figures 1 and 2), within the Iguaque–La Rusia–Guantiva Forest Conservation Corridor in the Central Colombian Andes. This region covers 100,000 ha., between 3,100 and 4,280 masl, has fairly high floristic diversity, and constitutes a strategic water reservoir for the region giving birth to numerous streams and a complex of lakes of glacial origin (Morales *et al.* 2007).

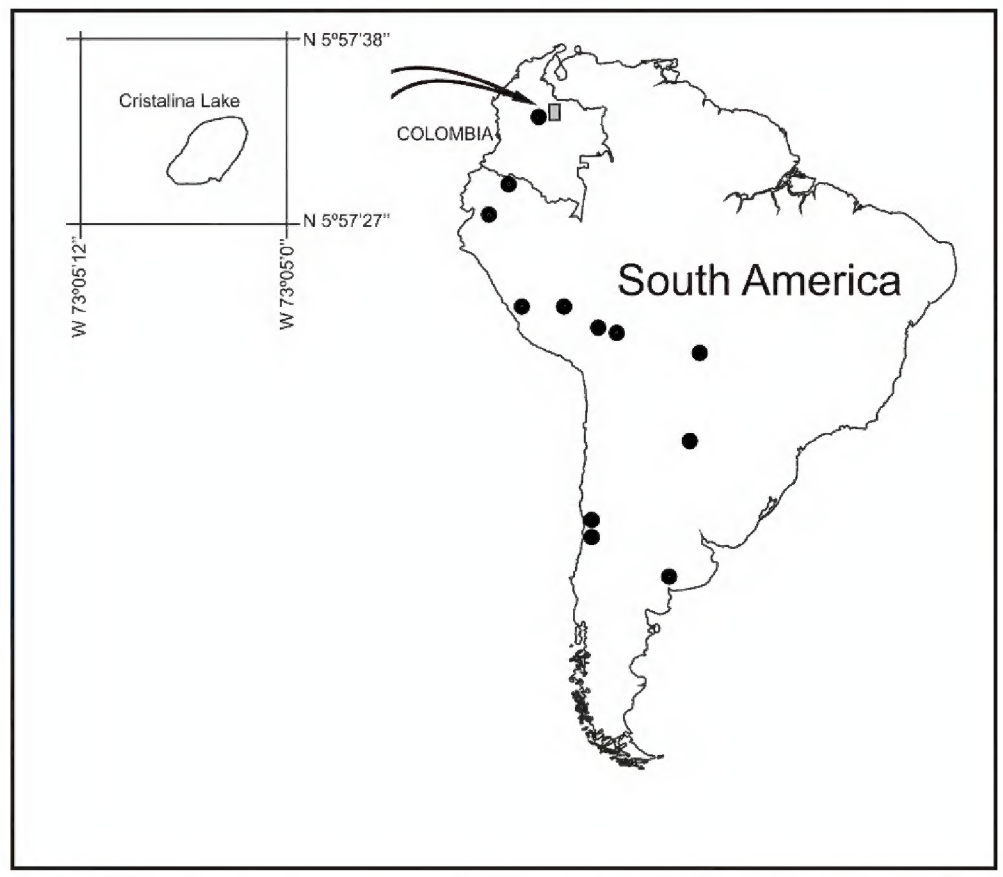

FIGURE 2. Distribution of *Girardia festae* (Platyhelminthes, Dugesiidae) records in South America (black circles), and location of the Colombian specimens discovered in this investigation (grey square)

We took sediment samples from vegetated beds (mainly phanerogams) at depths of 20-30 cm by means of corers (0.06 m^2) pushed 10 cm into the sediment. Additional water samples indicated an oligotrophic profile typical of undisturbed wetlands (*i.e.*, T 12.5°C, conductivity 8.2 $\mu S.cm^{-1}$, oxygen saturation 64%) (unpublished data). Sediment samples were sieved through a 100 µm mesh. We fixed retained macrofauna in 10% formalin in the field, and preserved it in 70% ethanol back at the lab. Planarians

Table 1. Freshwater planarians reported from Colombia, their localities and authority making the record. Altitude above sea level and latitude/longitude coordinates cited if available.

SPECIES	LOCALITY	AUTHORITY
Girardia cameliae	Near Medellín (06°15' N, 75°36' W)	Ball (1980)
	Cafetal La Camelia	Ball (1980)
	Guaca	Ball (1980)
	Antioquia (06°36' N, 75°39' W, 2,564 m to 05°35' N, 75°48' W, 1750 m)	Muñoz and Vélez (2007)
Girardia festae	Páramo Cruz Verde (3,200 m) (04°34' N, 74°02' W)	Fuhrmann (1914)
	Cristalina lake (3,745 m) (05°57' N, 73°05' W)	**This study**
Girardia longistriata	Ubaque lagoon (2,112 m)	Ball (1980)
	Páramo Cruz Verde (04°334' N, 74°02' W)	Ball (1980)
	Pedro Palo lake (2000 m) (04°34' N, 74°02' W)	Ball (1980)
Girardia paramensis	Sierra Nevada (3,400 m) (10°50' N, 73°40' W)	Sluys *et al.* (2005)
	Above Duriameina (3,400 m) (10°39' N, 73°39' W)	Sluys *et al.* (2005)
	Páramo Cruz Verde (3,200 m) (04°34' N, 74°02' W)	Ball (1980)
	Antioquia (between 06°36' N, 75°39' W, 2,564 m and 05°35' N, 75°48' W, 1750 m)	Muñoz and Vélez (2007)
Girardia tigrina	Antioquia (between 06°36' N, 75°39' W, 2,564 m and 05°35' N, 75°48' W, 1750 m)	Muñoz and Vélez (2007)

were dehydrated, mounted in paraplast, and cut sagittally in 6 µm-thick sections, then stained in Azan solution for histological examination. Tissues were examined under microscope. Post examination, this material was deposited in the Helminthological Collection of Museo de La Plata, Argentina (MLP 6290).

The specimens from Cristalina lake were identified as *Girardia festae*. This species has a highly variable reproductive anatomy (Marcus 1960). In our individuals, the testes were consistently located on the ventral surface, beneath the intestine, and extended from behind the ovaries to the posterior end of the body (Figure 3). This anatomic structure has been reported from other populations of the species (Du Bois-Reymond Marcus 1953). We also observed that both sperm ducts were widened ventro-distally in two vesicles filled with spermatozoids. These 'spermiducal vesicles' have been observed in specimens from Venezuela and Peru (Kawakatsu and Mitchell 1984). Moreover, in our specimens, the sperm ducts extended from behind the penis papilla and bent ventrally to join both sides of the bulbar cavity of the penis (Figure 4). The parallel ascending portions of sperm ducts and bulbar cavity were also filled with spermatozoids.

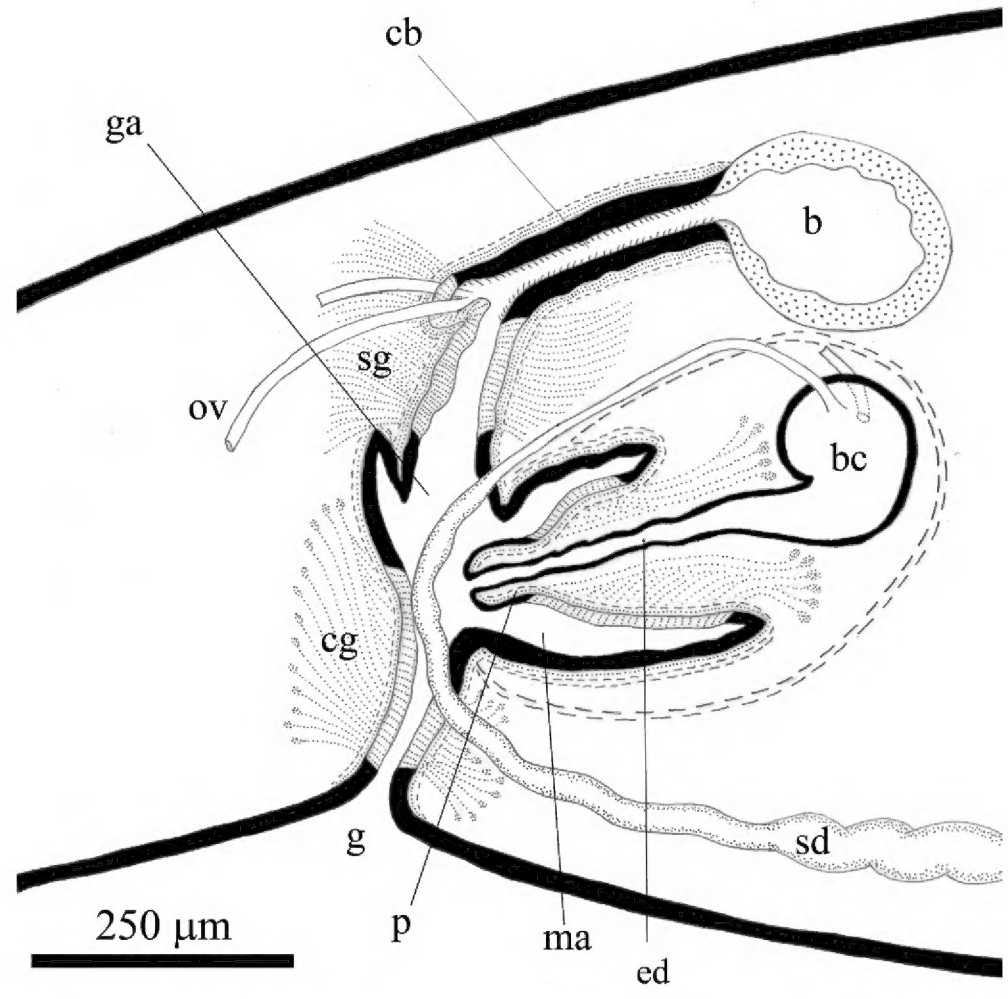

Figure 4. Diagrammatic reconstruction (in sagittal view) of the copulatory apparatus of *Girardia festae* (Platyhelminthes, Dugesiidae); (b) copulatory bursa, (bc) bulbar cavity, (cb) ciliated canal of the copulatory bursa, (cg) cement glands, (ed) ejaculatory duct, (g) gonopore, (ga) genital atrium, (ma) male atrium, (ov) oviducts, (p) penis papilla, (sd) sperm duct, (sg) shell glands.

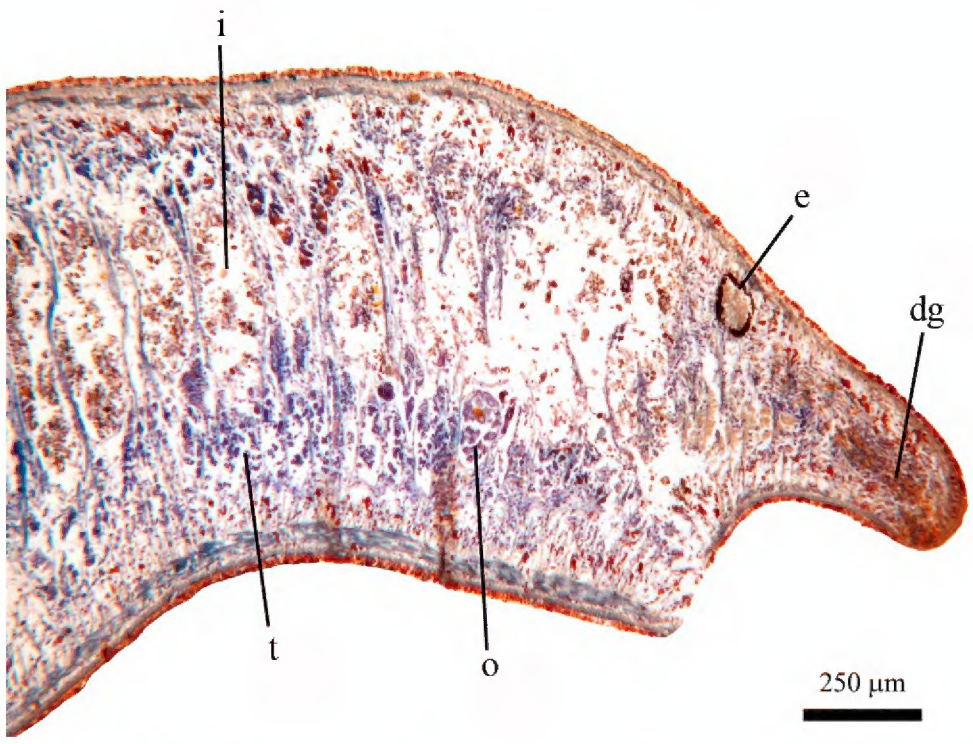

Figure 3. Sagittal section of the anterior body region of *Girardia festae* (Platyhelminthes, Dugesiidae) (head is on the right); (dg) duoglandular system, (e) eye, (i) intestine, (o) ovary, (t) testes.

The penis was typically made of a muscular and globoid bulb ending in a papilla, which can take different shapes within the species (Sluys 1992). Our specimens showed a stubby shaped papilla, approximately 250 µm in length (Figures 4-5), very similar to records from Brazil (Sluys *et al.* 2005). The epithelium of the penis papilla was cuboidal, coated with circular and longitudinal muscular fibers, both of the same width. The ejaculatory duct stemmed from the ventral region of the bulbar cavity, running concentrically through the papilla. We found two types of secretory cells that opened through the epithelium of the penis papila: cyanophil-secreting cells run from the penis bulb along the sides of the ejaculatory duct, while xanthophil-secreting cells, less numerous, were located in the papilla proper.

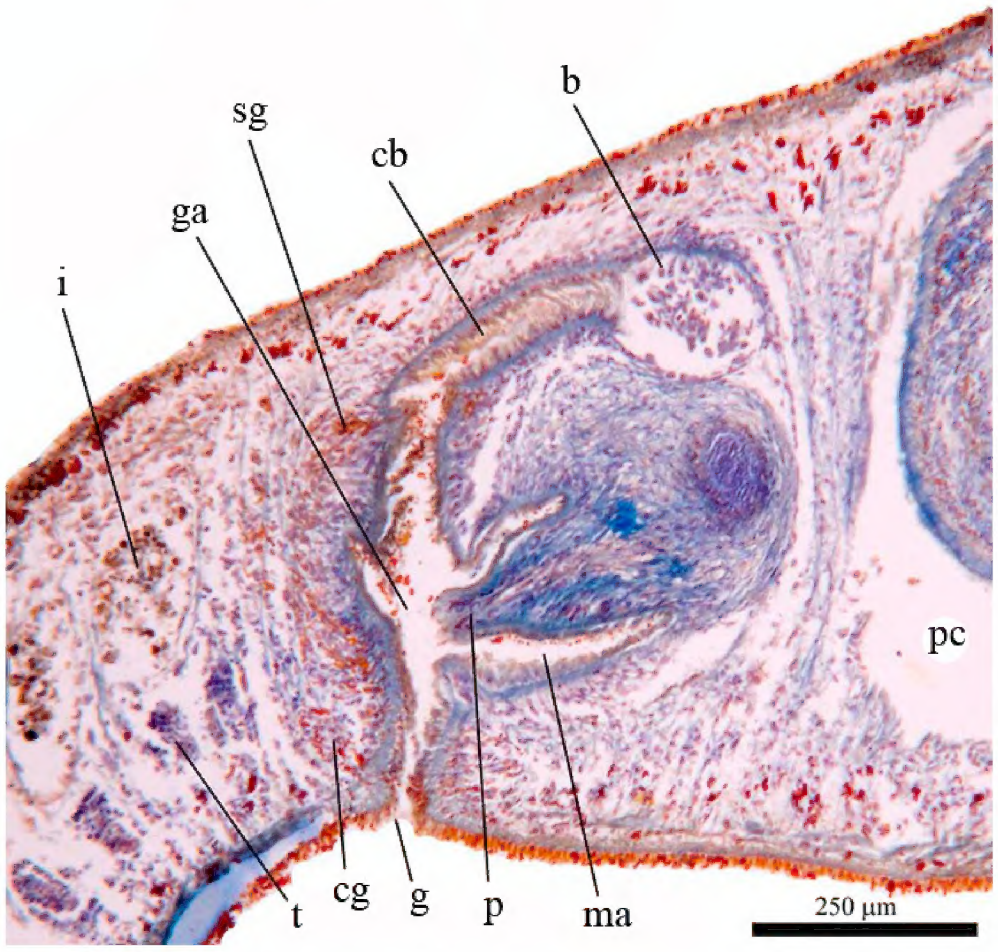

FIGURE 5. Sagittal section of the postpharyngeal region of *Girardia festae* (Platyhelminthes, Dugesiidae) (anterior tip is on the right); (b) copulatory bursa, (cb) ciliated canal of the copulatory bursa, (cg) cement glands, (g) gonopore, (ga) genital atrium, (i) intestine, (ma) male atrium, (p) penis papilla, (pc) pharyngeal cavity, (sg) shell glands, (t) testes.

The penis papilla occupied the entire male atrium. This atrium had a cylindrical epithelium, and subepithelial (circular) and inner (longitudinal) muscular fibers, the latter being three times thicker than the former. Ovaries were located ventrally behind the brain (Figure 3). Oviducts run from ovaries (beyond the gonopore) then bent dorsally before connecting to the canal of the copulatory bursa (Figure 4). The final portion of the oviducts and the anterior part of the canal of the copulatory bursa had numerous glands, with xanthophil granules. The canal of the bursa (~400 µm long) had a cylindrical ciliated epithelium with a circular subepithelial musculature layer thicker than the longitudinal layer. The copulatory bursa was relatively small (225 µm long, 175 µm wide), as described for specimens from Venezuela, Peru, Brazil and Paraguay (Kawakatsu and Mitchell 1984; Sluys *et al.* 2005). We found shell glands opening along the genital atrium (Figures 4-5).

We document the second record of *G. festae* in a Colombian high-altitude lake. Histological examination falls well within the pattern of variation in this species' reproductive features. Overall, Neotropical freshwater planarians have been poorly studied to date and, in particular, specimens have been frequently identified only at the generic level (*e.g.* Miserendino and Pizzolon 2003; Malone 2006; Tripole *et al.* 2008), often without a data source. We encourage local biologists to pursue full taxonomical description of these invertebrates by appropriately-skilled specialists, and so avoid the pitfalls of incomplete and incorrect identifications. Such information is essential for ascertaining reliable species' distributional patterns and setting up well-informed management programs (Bortolus 2008). To that end, this work is part of ongoing monitoring of the freshwater macrofauna of the Iguaque-La Rusia-Guantiva Paramo-Montane Forest Corridor.

As a whole, benthic invertebrates are key monitoring biota in aquatic ecosystems worldwide, and represent a main tool in assessing habitat quality of high-altitude lakes. Planarians are common taxa in freshwater research, their relative abundance being used for calculating biological indices in toxicology, biomonitoring and regeneration (Villar *et al.* 1994; Horvat *et. al.* 2005; Iannacone and Tejada 2007). These taxa may prove useful in future ecological and conservation studies targeting paramo ecosystems which currently face increasing rates of human alteration and the global effects of climate change.

TABLE 2. *Girardia festae* (Platyhelminthes, Dugesiidae) records including authority, study site and country. Altitude above sea level cited if available.

AUTHORITY	LOCALITY	COUNTRY
Borelli (1898)	Culebrillas lake (3,900 m)	Ecuador
	Near Cuenca (2,580 m)	Ecuador
	Cañar (3,176 m)	Ecuador
	Lake Yahuarcocha (2,253 m)	Ecuador
	Tulcán (2,977 m)	Ecuador
Fuhrmann (1914)	Paramo Cruz Verde	Colombia
De Beuchamp (1939)	Lake Titicaca	Peru and Bolivia
	La Paz (3,000m)	Bolivia
Du Bois-Reymond Marcus (1953)	Oxapampa (1,600-1,700 m)	Peru
	Near Tarma (3,400-4,000 m)	Peru
	Ticlio (4,800 m)	Peru
	Lima	Peru
	Acobamba (2,900 m)	Peru
	Lake Titicaca (3,815 m)	Peru
	Arequipa (2,300 m)	Peru
Hyman (1959)	Mapocho river	Chile
	Estero El Cobre	Chile
	Estero Guallilemu	Chile
	Estero Catapilco	Chile
	Estero Reñaca	Chile
	Estero Limache	Chile
	Quebrada El Tigre	Chile
Kawakatsu and Mitchell (1984)	Caracas	Venezuela
	Locality missing	Peru
Sluys (1992)	Springs of San Pedro	Curaçao
	Boca de León	Venezuela
Moretto (1996)	Mapocho river	Chile
Sluys *et al.* (2005)	Asunción	Paraguay
	Urucum (Mato Grosso)	Brazil
	Naposta stream (Bahía Blanca)	Argentina
Iannacone and Tejada (2007)	Turín river, Pachacamac, Lima	Peru

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